NASA STTR 2015 Phase I Solicitation

T11 Modeling, Simulation, Information Technology and Processing

Lead Center: HQ

Modeling, Simulation, Information Technology and Processing consists of four technology subareas, including computing, modeling, simulation, and information processing. NASA’s ability to make engineering breakthroughs and scientific discoveries is limited not only by human, robotic, and remotely sensed observation, but also by the ability to transport data and transform the data into scientific and engineering knowledge through sophisticated needs. With data volumes exponentially increasing into the petabyte and exabyte ranges, modeling, simulation, and information technology and processing requirements demand advanced supercomputing capabilities.

Subtopics

T11.01 Information Technologies for Intelligent and Adaptive Space Robotics

Lead Center: ARC

Participating Center(s): JPL, JSC

The objective of this subtopic is to develop information technologies that enable robots to better support space exploration. Improving robot information technology (algorithms and software) is critical to improving the capability, flexibility, and performance of future missions. In particular, the NASA "Robotics, Tele-Robotics, and Autonomous Systems" roadmap (TA04) indicates that extensive and pervasive use of robots can significantly enhance exploration missions that are progressively longer, complex, and operate with fewer ground control resources.

The performance of intelligent robots is directly linked to the quality and capability of the information technologies used to build and operate them. Thus, proposals are sought that address the following technology needs:

- Advanced robot user interfaces that facilitate distributed collaboration, geospatial data visualization, summarization and notification, performance monitoring, and physics-based simulation. This does NOT include user interfaces for direct teleoperation / purely manual control, telepresence, or virtual reality. The primary objective is to enable more effective and efficient interaction with robots remotely operated with discrete commands or supervisory control.
- Mobile robot navigation for operations in man-made (inside the International Space-Station) and unstructured environments (asteroids, Moon, Mars). Emphasis on multi-sensor data fusion, obstacle detection, and proximity ops. The primary objective is to radically and significantly increase the performance of mobile robot navigation through advanced on-board sensors, perception algorithms and software.
- Robot software architecture that supports adjustable autonomy, on-board health management and prognostics, automated data triage, data management, and data distribution (middleware). The primary

objective is to facilitate the creation, extensibility and maintenance of complex robot systems.

Deliverables to NASA:

- Identify scenarios and use cases.
- Define specifications based on design trades.
- Develop concepts to address use cases.
- Build and test prototype systems.
- Perform technology demonstrations.

T11.02 Computational Simulation and Engineering

Lead Center: JPL

Computational Optimization

Proposals are solicited for developing numerical methods and tools that enable robust continuous and discrete optimization as well as uncertainty quantification for physics based computational models. There are many different optimization methods and implementations of some of these methods are available in commercial and open-source form. These methods typically use a “function call” to evaluate a performance model to be optimized. We seek proposals to develop new methods and tools for developing an integrated performance model that represents the behavior of a system (or component) by integrating multi-disciplinary performances. We are not interested in discipline-specific performance models (e.g., a FEA model of a solar panel dynamics). We are interested in model representations that capture different physical phenomena in a system (e.g., structural, dynamic, thermal, geometry, etc.). Our objective is to enable automated and/or human-in-the-loop optimization of complex, multi-disciplinary system models. We are also interested in uncertainty quantification of these models. Methods or tools that leverage discipline-specific, commercial packages that are commonly used in engineering design at NASA and other relevant fields (e.g.,DoD, automotive, aerospace, etc.) are of high interest.

The integrated performance model should clearly demonstrate how it may be used to first evaluate performance against different requirements and then improved (automated or human-guided) to give an optimal performance (in a weighted sum manner) against the different requirements. Intrinsic in this is the parameterization of the discipline-specific aspects of the performance model and exposing the parameters for optimization. In Phase I, it is expected that the proposer will demonstrate integration of at least two different disciplines. One of these disciplines should be geometry via Computer Aided Design software. If successful, Phase II will mature the work-flow and develop integration with a number of different discipline specific tools. Given the maturity of discipline specific tools, we expect the TRL level at the end of Phase II to be 4-6.

Virtual Worlds

Proposals are solicited for development of computational tools that enable rapid demonstration of mission concepts. The intent of such a tool is to enable non-experts in animation to rapidly build mission scenarios and visually express their concepts in a virtual world. These tools should enable full 3-D visualization by importing of CAD parts of electromechanical systems (e.g., rovers, landers, orbiters), environment models (height field maps with textures for terrain, star maps and planetary bodies), animation functionality to show temporal progression and movement of appropriate objects in the scene. The tool should support animation of flexible bodies (e.g., solar panel vibrations) along with articulation of components. The tool should feature a ray-tracing engine for good quality visualization with shadowing, ambient lighting, etc. The tool should also be able to demonstrate terrain artifacts such as rocks, dust and ejecta as both static and dynamic objects. An example of a static artifact may be a rock pile that does not move during the animation while a dynamic artifact may be dust rising from a lander thruster interaction with terrain. Note that the emphasis is on visualization and not necessarily on the physics of the problem. However, the tool should have API for integration with physics engines (e.g., ODE, Bullet, Proprietary Code) so that physics simulations can be used to control temporal progression of a scene. There should also be a functionality to write simple scripts for animating the virtual entities. There should be an avenue for developing a library of animation objects (e.g., rovers, terrains and locations) for re-use in later concept developments. The tools should be cross platform and enable development of animations or movies. The tool should take advantage of graphics processors or enable use of cluster computers for fast rendering of complex scenes. Alternately, the tool could feature a server-based functionality where the front-end user-interactions are through a webpage (using Java, HTML or other alternatives) and the computations are remotely conducted. Support for multiple concurrent users for content creating is desired. Ease of user interaction is key to the success of the tools. It is expected that at the end of Phase I, the performer will deliver an architecture document that captures the full intent of the tool. Similarly, performer will deliver software prototype of the implementation of the tool. It is expected that the software at the end of Phase I will be a prototype and may not have all features implemented or debugged. Performer will identify options for desired licensing options for the software to be developed for Phase II. At the end of Phase II, the performer will deliver all source code associated with the tool and verification test cases demonstrating all the proposed features within the software. The performer will also deliver a document summarizing the installation and usage of the tool and appropriate licensing options. In case of use of any third party software (e.g., open-source code) in this effort, the performer will deliver an acknowledgement that they have complied with appropriate licensing agreements. The anticipated TRL level at the end of Phase II is 5-6.